

CLAIMS

- 1 1. A packet-buffering system in a communication device for transferring packets received
2 over a communications network from an input port to an output port of the communication
3 device, the system comprising:

4 a first-level memory segmented into a plurality of first-level queues each having a first-
D,
5 buffer depth, the plurality of first-level queues receiving the packets from the input port of the
communication device; and

³¹⁴
a second-level memory in communication with the first-level memory and the output port, the second-level memory being segmented into a plurality of second-level queues each having a second-buffer depth and being associated with the output port of the communication device, the plurality of second-level queues receiving packet data from at least one of the plurality of first-level queues and transferring the packet data to the output port.

wherein a sum of the second-buffer depths exceeds a sum of the first-buffer depths.

- 1 2. The packet-buffering system of claim 1, wherein the plurality of first-level queues each
2 have a first-buffer bandwidth and the plurality of second-level queues each have a second-buffer
3 bandwidth, wherein a sum of the second-buffer bandwidths is equal to or greater than a sum of
4 the first-buffer bandwidths.

1 3. The packet-buffering system of claim 2, wherein the sum of the first-buffer bandwidths is
2 not less than an aggregate bandwidth of the communications network.

1 4. — The packet-buffering system of claim 1, wherein the first and second-level memories are
2 ^{FIG 2A}
3 implemented in a fully connected mesh architecture having a plurality of input ports and a
4 plurality of output ports, each input port being continuously connected to a corresponding output
port.

1 5.— The packet-buffering system of claim 1, wherein the first and second-level memories are
2 ^{FIG 2B, 2C}
3 implemented in a partially connected mesh architecture having a plurality of input ports and a
4 plurality of output ports, at least one of the input ports being switchably connected to at least one
of the output ports.

1 6.— The packet-buffering system of claim 1, wherein the received packets have priority levels
2 associated therewith, each of the plurality of second-level queues being assigned a priority level
3 and receiving packets having a priority level consistent therewith.

1 7. The packet-buffering system of claim 6, further comprising
2 a scheduler in communication with the plurality of second-level queues, the scheduler
3 donating bandwidth from one of the plurality of second-level queues with a first priority level to

4 another of the plurality of second-level queues with a second priority level, wherein the first
5 priority level is higher than the second priority level.

1 8. — The packet-buffering system of claim 6, further comprising
2 a scheduler in communication with the plurality of second-level queues, the scheduler
3 donating bandwidth from one of the plurality of second-level queues with a first priority level to
4 another of the plurality of second-level queues with a second priority level, wherein the first
5 priority level is lower than the second priority level.

1 9. — The packet-buffering system of claim 1, further comprising
2 a scheduler in communication with the plurality of second-level queues, the scheduler
3 independently scheduling packets received by the plurality of second-level queues on a pure
4 priority basis.

1 10. — The packet-buffering system of claim 1, further comprising
2 a scheduler in communication with the plurality of second-level queues, the scheduler
3 independently scheduling packets received by the plurality of second-level queues using a
4 weighted fair queuing technique.

1 11. The packet-buffering system of claim 1, further comprising
2 a scheduler in communication with the plurality of second-level queues, the scheduler
3 independently scheduling packets received by the plurality of second-level queues using a
4 random early detection technique.

1 12. ~ The packet-buffering system of claim 1, further comprising
2 a scheduler in communication with the plurality of second-level queues, the scheduler
3 independently scheduling packets received by the plurality of second-level queues using a
4 weighted random early detection technique.

1 13. ~ The packet-buffering system of claim 1, further comprising
2 a scheduler in communication with the plurality of second-level queues, the scheduler
3 independently scheduling packets received by the plurality of second-level queues using a
4 bandwidth donation technique.

1 14. ~ The packet-buffering system of claim 1, further comprising
2 a scheduler in communication with the plurality of second-level queues, the scheduler
3 independently scheduling packets received by the plurality of second-level queues by using a
4 combination of techniques selected from pure priority, weighted fair queuing, random early
5 detection, weighted random early detection, and bandwidth donation.

1 15. — The packet-buffering system of claim 1, wherein the first-level memory is composed of a
2 first memory type and the second-level memory is composed of a second memory type, the
3 second memory type having performance characteristics substantially similar to the first memory
4 type.

1 16. The packet-buffering system of claim 1, wherein the first-level memory is composed of a
2 first memory type and the second-level memory is composed of a second memory type, the
3 second memory type having performance characteristics substantially different from that of the
4 first memory type.

17. A hierarchical packet-buffering system in a communication device for connection to a
network having a first network bandwidth, the system comprising:

312 a first packet buffer capable of receiving data packets from the communication device
over the network, the first packet buffer comprising a plurality of queues and having a³²⁰⁻³²⁴ first
5 packet-buffer bandwidth] and a first packet-buffer depth; and

314 a plurality of second packet buffers in communication with the first packet buffer, each
of the plurality of second packet buffers being associated with and receiving packets from at least
8 one of the plurality of queues of the first packet buffer, each of the plurality of second packet
9 buffers having a[second packet-buffer bandwidth] and a second packet-buffer depth,³³⁰⁻³³⁴

10 wherein

11 i) a sum of the second packet-buffer depths exceeds the first packet-buffer depth,

- 12 ii) a sum of the second packet-buffer bandwidths is equal to or greater than the
13 first packet-buffer bandwidth, and
14 iii) the first packet-buffer bandwidth is greater than or equal to the first network
15 bandwidth.

1 18. The hierarchical packet-buffering system of claim 17, wherein the communication device
2 is one of a plurality of communication devices interconnected to provide direct connections
3 between each of the plurality of communication devices, wherein the hierarchical packet-
4 buffering system contained in each of the plurality of communication devices is not shared by the
5 plurality of communication devices.

1 19. The hierarchical packet-buffering system of claim 17, wherein the first packet buffer
2 comprises a packet buffer embedded in an ASIC.

1 20. The hierarchical packet-buffering system of claim 17, wherein each of the plurality of
2 second packet buffers comprises field configurable memory elements.

1 21. The hierarchical packet-buffering system of claim 17, further comprising a plurality of
2 third packet buffers in communication with at least one of the plurality of second packet buffers,
3 each of the plurality of third packet buffers being associated with and receiving packets from the
4 at least one of the plurality of queues from the at least one of the plurality of second packet

5 buffers, each of the plurality of third packet buffers having a third packet-buffer bandwidth and a
Dx
6 third packet-buffer depth, wherein a sum of the third packet-buffer bandwidths associated with
7 the at least one of the plurality of queues of the at least one second packet buffer is equal to or
8 greater than the at least one second packet-buffer bandwidth, and wherein a sum of the third
9 packet-buffer depths associated with the at least one of the plurality of queues of the at least one
10 second packet buffer exceeds the second packet-buffer depth of the at least one second packet
11 buffer.

22.15 The hierarchical packet-buffering system of claim 17, wherein the first packet buffer is
composed of a first memory type and the second packet buffers are composed of a second
memory type, the second memory type having performance characteristics substantially similar to
the first memory type.

23.16 The hierarchical packet-buffering system of claim 17, wherein the first packet buffer is
composed of a first memory type and the second packet buffers are composed of a second
3 memory type, the second memory type having performance characteristics substantially different
4 from that of the first memory type.

1 24.17 The hierarchical packet-buffering system of claim 17, wherein the first and second packet
2 buffers are implemented in a fully connected mesh architecture having a plurality of input ports

3 and a plurality of output ports, each input port being continuously connected to a corresponding
4 output port.

1 25./⁵ The hierarchical packet-buffering system of claim 17, wherein the first and second packet
2 buffers are implemented in a partially connected mesh architecture having a plurality of input
3 ports and a plurality of output ports, at least one of the input ports being switchably connected to
4 at least one of the output ports.

1 26.)⁶ The hierarchical packet-buffering system of claim 17, wherein the data packets received
2 by the first packet buffer have priority levels associated therewith, each of the plurality of second
3 packet buffers being assigned a priority level and receiving packets having a priority level
4 consistent therewith.

1 27./⁷ The hierarchical packet-buffering system of claim 26, further comprising
2 a scheduler in communication with the plurality of second packet buffers, the scheduler
3 donating bandwidth from one of the plurality of second packet buffers with a first priority level
4 to another of the plurality of second packet buffers with a second priority level, wherein the first
5 priority level is higher than the second priority level.

1 28. The hierarchical packet-buffering system of claim 26, further comprising
18
2 a scheduler in communication with the plurality of second packet buffers, the scheduler
3 donating bandwidth from one of the plurality of second packet buffers with a first priority level
4 to another of the plurality of second packet buffers with a second priority level, wherein the first
5 priority level is lower than the second priority level.

1 29./₇ The hierarchical packet-buffering system of claim 17, further comprising
2 a scheduler in communication with the plurality of second packet buffers, the scheduler
3 independently scheduling packets received by the plurality of second packet buffers on a pure
4 priority basis.

1 30./₁₀ The hierarchical packet-buffering system of claim 17, further comprising
2 a scheduler in communication with the plurality of second packet buffers, the scheduler
3 independently scheduling packets received by the plurality of second packet buffers using a
4 weighted fair queuing technique.

1 31./₁₁ The hierarchical packet-buffering system of claim 17, further comprising
2 a scheduler in communication with the plurality of second packet buffers, the scheduler
3 independently scheduling packets received by the plurality of second packet buffers using a
4 random early detection technique.

1 32. The hierarchical packet-buffering system of claim 17, further comprising
12
2 a scheduler in communication with the plurality of second packet buffers, the scheduler
3 independently scheduling packets received by the plurality of second packet buffers using a
4 weighted random early detection technique.

1 33./₁₃ The packet-buffering system of claim 17, further comprising
2 a scheduler in communication with the plurality of second packet buffers, the scheduler
3 independently scheduling packets received by the plurality of second packet buffers using a
4 bandwidth donation technique.
5

1 34./₁₄ The packet-buffering system of claim 17, further comprising
2 a scheduler in communication with the plurality of second packet buffers, the scheduler
3 independently scheduling packets received by the plurality of second packet buffers by using a
4 combination of techniques selected from pure priority, weighted fair queuing, random early
5 detection, weighted random early detection, and bandwidth donation.

1 (35.) ^{Fig 3} A hierarchical packet-buffering system for transferring packets from a series of input
2 ports to a series of output ports, at least some of the input ports being continuously connected to
3 corresponding output ports, the system comprising:

4 a first packet buffer organized into a first series of queues comprising a plurality of
5 priority queue sets, each first-series priority queue set comprising a plurality of the first-series
6 queues and being associated with one of the output ports, each of the first-series queues having a
7 first-series queue size;

8 a second packet buffer receiving packets from the first packet buffer, the second packet
9 buffer being organized into a second series of queues comprising a plurality of priority queue
10 sets, each second-series priority queue set comprising a plurality of the second-series queues and
11 being associated with one of the output ports, each of the second-series queues having a second-
12 series queue size larger than the size of a corresponding first-series queue;

13 a plurality of de-queuing systems, each of the de-queuing systems being assigned to one
14 of the second-series queues and scheduling packets stored therein for output on one of the output
15 ports; and

16 a forwarding engine for examining each of the packets received on the input ports and
17 enabling transfer of each the packet to a selected one of the first-series queues,

18 wherein

19 packets arrive at the input ports and are transferred to the first-series queues at an
20 aggregate network rate, and packets being received by the second-series queues are
21 transferred at a rate less than the aggregate network rate.

1 36.12 The hierarchical packet-buffering system of claim 35, wherein the first-series queues each
2 have a first-buffer bandwidth and the second-series queues each have a second-buffer bandwidth,

3 wherein a sum of the second-buffer bandwidths is equal to or greater than a sum of the first-
4 buffer bandwidths.

1 37.¹³ The hierarchical packet-buffering system of claim 36, wherein the sum of the first-buffer
2 bandwidths is not less than an aggregate bandwidth of a communications network coupled to the
3 input ports.

1 38.¹⁴ The hierarchical packet-buffering system of claim 35, wherein the first and second packet
2 buffers are implemented in a fully connected mesh architecture.

1 39.¹⁵ The hierarchical packet-buffering system of claim 35, wherein the first and second packet
2 buffers are implemented in a partially connected mesh architecture.

1 40.¹⁶ The hierarchical packet-buffering system of claim 35, wherein the transferred packets
2 each have associated priority levels, the associated priority levels corresponding to at least one of
3 the plurality of first-series priority queue sets and to at least one of the plurality of second-series
4 priority queue sets.

1 41.¹⁷ The hierarchical packet-buffering system of claim 40, further comprising
2 a scheduler in communication with the plurality of second-series priority queue sets, the
3 scheduler donating bandwidth from one of the plurality of second-series priority queue sets with

- 4 a first priority level to another of the plurality of second-series priority queue sets with a second
- 5 priority level, wherein the first priority level is higher than the second priority level.

1 42. /₈ The hierarchical packet-buffering system of claim 40, further comprising
2 a scheduler in communication with the plurality of second-series priority queue sets, the
3 scheduler donating bandwidth from one of the plurality of second-series priority queue sets with
4 a first priority level to another of the plurality of second-series priority queue sets with a second
5 priority level, wherein the first priority level is lower than the second priority level.

1 43. /₉ The hierarchical packet-buffering system of claim 35, further comprising
2 a scheduler in communication with the plurality of second-series priority queue sets, the
3 scheduler independently scheduling packets received by the plurality of second-series priority
4 queue sets on a pure priority basis.

1 44. /₁₀ The hierarchical packet-buffering system of claim 35, further comprising
2 a scheduler in communication with the plurality of second-series priority queue sets, the
3 scheduler independently scheduling packets received by the plurality of second-series priority
4 queue sets using a weighted fair queuing technique.

1 45. The hierarchical packet-buffering system of claim 35, further comprising
1 a scheduler in communication with the plurality of second-series priority queue sets, the
2 scheduler independently scheduling packets received by the plurality of second-series priority
3 queue sets using a random early detection technique.

1 46./₁₂ The hierarchical packet-buffering system of claim 35, further comprising
2 a scheduler in communication with the plurality of second-series priority queue sets, the
3 scheduler independently scheduling packets received by the plurality of second-series priority
4 queue sets using a weighted random early detection technique.

1 47./₁₃ The packet-buffering system of claim 35, further comprising
2 a scheduler in communication with the plurality of second-series priority queue sets, the
3 scheduler independently scheduling packets received by the plurality of second-series priority
4 queue sets using a bandwidth donation technique.

1 48./₁₄ The packet-buffering system of claim 35, further comprising
2 a scheduler in communication with the plurality of second-series priority queue sets, the
3 scheduler independently scheduling packets received by the plurality of second-series priority
4 queue sets by using a combination of techniques selected from pure priority, weighted fair
5 queuing, random early detection, weighted random early detection, and bandwidth donation.

1 (49) A method of buffering packets in a communication device, the method comprising the
2 steps of:

3 receiving the packets at an input port of the communication device;
4 providing first-level queues associated with the input port and having a first-buffer depth,
5 the first-level queues receiving the packets from the input port;

6 selecting an output port of the communication device as a destination for the received
7 packets;

8 providing second-level queues associated with the selected output port and corresponding
9 to the first-level queues, the second-level queues having a second-buffer depth exceeding the
10 first-buffer depth of the first-level queues;

11 transferring the received packets from the first-level queues to corresponding second-
12 level queues; and

13 transmitting the transferred packets in the second-level queues to the selected output port.

1 50. / The method of claim 49, further comprising the steps of:

2 determining a priority level associated with the received packets;
3 assigning the priority level to at least one of the second-level queues; and
4 transferring the received packets from the first-level queues to the at least one of the
5 second-level queues assigned to that priority level.

- 1 51. ¹⁷ The method of claim 50, further comprising the step of donating bandwidth from one of
2 the second-level queues with a first priority level to another of the second-level queues with a
3 second priority level, wherein the first priority level is higher than the second priority level.

- 1 52./₈ The method of claim 50, further comprising the step of donating bandwidth from one of
2 the second-level queues with a first priority level to another of the second-level queues with a
3 second priority level, wherein the first priority level is lower than the second priority level.

53. ¹⁹ The method of claim 49 further comprising the step of independently scheduling packets
received by the second-level queues on a pure priority basis.

54. ¹⁶ The method of claim 49 further comprising the step of independently scheduling packets
received by the second-level queues using a weighted fair queuing technique.

- 1 55. ¹¹ The method of claim 49 further comprising the step of independently scheduling packets
2 received by the second-level queues using a random early detection technique.

- 1 56. ¹² The method of claim 49 further comprising the step of independently scheduling packets
2 received by the second-level queues using a weighted random early detection technique.

- 1 57.¹² The method of claim 49 further comprising the step of independently scheduling packets
2 received by the second-level queues using a bandwidth donation technique.

- 1 58.¹⁴ The method of claim 49 further comprising the step of independently scheduling packets
2 received by the second-level queues using a combination of techniques selected from pure
3 priority, weighted fair queuing, random early detection, weighted random early detection, and
4 bandwidth donation.

1 59. The method of claim 49, wherein

- 2 i) the step of providing first-level queues further comprises receiving the packets at an
3 aggregate network rate of the communication device, and
4 ii) the transferring step comprises buffering the transferred packets in the second-level
5 queues at a rate less than the aggregate network rate.

- 1 60. The method of claim 49, wherein the received packets have forwarding attributes
2 associated therewith, and further comprising the steps of:
3 aggregating the received packets with substantially similar forwarding attributes into
4 queue flows; and
5 routing the queue flows into the first-level queues.

1 61. ^{1/4} The method of claim 49 further comprising the step of continuously coupling the input
2 port to the selected output port.

1 62. ^{1/5} The method of claim 49 further comprising the step of switchably coupling the input
2 port to the selected output port.

1 63. The method of claim 49 further comprising the steps of:
2 providing a first memory element having a first set of performance characteristics;
3 forming the first-level queues within the first memory element;
4 providing a second memory element having a second set of performance characteristics,
5 the second set of performance characteristics being substantially similar to the first set of
6 performance characteristics; and
7 forming the second-level queues within the second memory element.

1 64. The method of claim 49 further comprising the steps of:
2 providing a first memory element having a first set of performance characteristics;
3 forming the first-level queues within the first memory element;
4 providing a second memory element having a second set of performance characteristics,
5 the second set of performance characteristics differing from the first set of performance
6 characteristics; and
7 forming the second-level queues within the second memory element.

- 1 (65.) A method of buffering data in a packet-buffering system of a communication device for
2 connection to a network having a first network bandwidth, the method comprising the steps of:

3 providing a first packet buffer capable of receiving data packets from the communication
4 device over the network, the first packet buffer comprising a plurality of queues and having a
5 [first packet-buffer bandwidth] and a first packet-buffer depth;

6 providing a plurality of second packet buffers in communication with the first packet
7 buffer, each of the second packet buffers being associated with and receiving packets from at
8 least one of the plurality of queues of the first packet buffer, each of the second packet buffers
9 having a[second packet-buffer bandwidth] and a second packet-buffer depth, wherein
10 i) a sum of the second packet-buffer depths exceeds the first packet-buffer
11 depth,
12 ii) a sum of the second packet-buffer bandwidths is equal to or greater than
13 the first packet-buffer bandwidth, and
14 iii) the first packet-buffer bandwidth is greater than or equal to the first
15 network bandwidth;

16 receiving the data packets in at least one of the plurality of queues of the first packet
17 buffer, the data packets being received from an input port of the communication device; and
18 routing packets from the queues of the first packet buffer to corresponding queues of
19 second packet buffer, the corresponding queues transferring the routed packets to an output port
20 of the communication device.

1 66. The method of claim 65, further comprising the steps of:
2 determining a priority level associated with the data packets received from the input port;
3 assigning the priority level to at least one of the second packet buffers; and
4 routing the received packets from the first-level queues to the at least one of the second
5 packet buffers assigned to that priority level.

1 67./₇ The method of claim 65, further comprising the step of donating bandwidth from one of
2 the second packet buffers with a first priority level to another of the second-level queues with a
3 second priority level, wherein the first priority level is higher than the second priority level.

1 68./₈ The method of claim 65, further comprising the step of donating bandwidth from one of
2 the second packet buffers with a first priority level to another of the second packet buffers with a
3 second priority level, wherein the first priority level is lower than the second priority level.

1 69./₉ The method of claim 65 further comprising the step of independently scheduling packets
2 received by the second packet buffers on a pure priority basis.

1 70./₁₀ The method of claim 65 further comprising the step of independently scheduling packets
2 received by the second packet buffers using a weighted fair queuing technique.

1 71. /₁ The method of claim 65 further comprising the step of independently scheduling packets
2 received by the second packet buffers using a random early detection technique.

1 72. /₂ The method of claim 65 further comprising the step of independently scheduling packets
2 received by the second packet buffers using a weighted random early detection technique.

1 73. /₃ The method of claim 65 further comprising the step of independently scheduling packets
2 received by the second packet buffers using a bandwidth donation technique.

1 74. /₄ The method of claim 65 further comprising the step of independently scheduling packets
2 received by the second packet buffers using a combination of techniques selected from pure
3 priority, weighted fair queuing, random early detection, weighted random early detection, and
4 bandwidth donation.

1 75. The method of claim 65, further comprising the steps of:
2 receiving the data packets at an aggregate network rate of the communication device by
3 the queues of the first packet buffer; and
4 buffering the packets received from the first packet buffer by the second packet buffers at
5 a rate less than the aggregate network rate.

1 76. The method of claim 65 further comprising the steps of:
2 aggregating the packets received at the input port according to substantially similar
3 forwarding attributes associated therewith, the aggregated packets forming queue flows; and
4 routing the queue flows into the plurality of queues of the first packet buffer.

1 77. The method of claim 65 further comprising the step of continuously coupling the input
2 port to the output port.

1 78. The method of claim 65 further comprising the step of switchably coupling the input
2 port to the output port.

1 79. The method of claim 65 further comprising the steps of:
2 providing a first memory element having a first set of performance characteristics;
3 forming the first packet buffer within the first memory element;
4 providing a second memory element having a second set of performance characteristics,
5 the second set of performance characteristics being substantially similar to the first set of
6 performance characteristics; and
7 forming the second packet buffers within the second memory element.

1 80. The method of claim 65 further comprising the steps of:
2 providing a first memory element having a first set of performance characteristics;
3 forming the first packet buffer within the first memory element;
4 providing a second memory element having a second set of performance characteristics,
5 the second set of performance characteristics differing from the first set of performance
6 characteristics; and
7 forming the second packet buffers within the second memory element.

1 X (81). A method of buffering queues in a hierarchical packet-buffering system coupled to a
2 network, comprising the steps of:
3 receiving data packets over the network, the data packets having forwarding attributes
4 associated therewith;
5 aggregating data packets with substantially similar forwarding attributes into queue
6 flows;
7 routing at least one of the queue flows into a plurality of first packet buffers, each of the
8 plurality of first packet buffers having a(first packet-buffer bandwidth)and first packet-buffer
9 depth;
10 routing a subset of the at least one of the queue flows from at least one of the plurality of
11 first packet buffers into a plurality of second packet buffers associated with the at least one of
12 the queue flows, each of the plurality of second packet buffers having a(second packet-buffer
13 bandwidth)and a second packet-buffer depth, wherein a sum of the first packet-buffer

14 bandwidths associated with the at least one of the queue flows is less than or equal to a
15 corresponding sum of the associated second packet-buffer bandwidths.

1 X (82) A method of transferring packets from a series of input ports to a series of output ports,
2 each of the input ports being continuously connected to all of the output ports, the method
3 comprising the steps of:

4 providing a first packet buffer organized into a first series of queues comprising a
5 plurality of priority queue sets, each first-series priority queue set comprising a plurality of the
6 first-series queues and being associated with one of the output ports and a priority level, each of
7 the first-series queues having a first-series queue size;

8 providing a second packet buffer organized into a second series of queues comprising a
9 plurality of priority queue sets, each second-series priority queue set comprising a plurality of the
10 second-series queues and being associated with one of the output ports and a priority level, each
11 of the second-series queues having a second-series queue size larger than the size of the
12 corresponding first-series queue;

13 receiving packets at the input ports at an aggregate network rate, the received packets
14 having forwarding attributes associated therewith;

15 examining, at the aggregate network rate, each of the received packets and assigning a
16 priority and an output port thereto;

17 transferring, at the aggregate network rate and in accordance with the assigned priority
18 level, packets from each of the input ports to one of the first-series priority queues of the first-
19 series queue set associated with the assigned output port;

20 transferring, at a rate less than the aggregate network rate, packets from the first-series
21 queues to corresponding ones of the second-series queues, packets being transferred from the
22 first-series queues to the second-series queues in an order according with their priority levels; and
23 scheduling packets stored in the second-series queues for transmission at the assigned
24 output port.

1 83. The method of claim 82, further comprising the steps of:
2 determining a priority level associated with the packets received at the input ports; and
3 assigning the priority level to at least one of the second-series queue sets.

4 84. | 7 The method of claim 83 further comprising the step of donating bandwidth from one of
5 the plurality of second-series priority queue sets with a first priority level to another of the
6 plurality of second-series priority queue sets with a second priority level, wherein the first
7 priority level is higher than the second priority level.

8 85. | 8 The method of claim 83 further comprising the step of donating bandwidth from one of
9 the plurality of second-series priority queue sets with a first priority level to another of the
10 plurality of second-series priority queue sets with a second priority level, wherein the first
11 priority level is lower than the second priority level.

1 86. /₉ The method of claim 82 further comprising the step of independently scheduling packets
2 received by the plurality of second-series priority queue sets on a pure priority basis.

1 87. /₁₀ The method of claim 82 further comprising the step of independently scheduling packets
2 received by the plurality of second-series priority queue sets using a weighted fair queuing
3 technique.

1 88. /₁₁, The method of claim 82 further comprising the step of independently scheduling packets
2 received by the plurality of second-series priority queue sets using a random early detection
3 technique.

1 89. /₁₂ The method of claim 82 further comprising the step of independently scheduling packets
2 received by the plurality of second-series priority queue sets using a weighted random early
3 detection technique.

1 90. /₁₃ The method of claim 82 further comprising the step of independently scheduling packets
2 received by the plurality of second-series priority queue sets using a bandwidth donation
3 technique.

1 91, The method of claim 82 further comprising the step of independently scheduling packets
17
2 received by the plurality of second-series priority queue sets using a combination of techniques
3 selected from pure priority, weighted fair queuing, random early detection, weighted random
4 early detection, and bandwidth donation.

1 92. The method of claim 82, further comprising the steps of:
2 aggregating the received packets with substantially similar forwarding attributes into
3 queue flows; and
4 routing the queue flows into the first-series priority queues.

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